

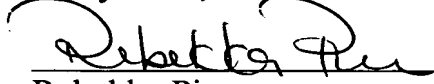
Docket No.: 2004P02085

CERTIFICATION

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English and German languages, and that I believe that the attached text is a true and complete translation of PCT/EP2005/050889, filed with the European Patent Office on March 1, 2005.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Hollywood, Florida .

  
Rebekka Pierre

September 5, 2006

Lerner Greenberg Sterner LLP  
P.O. Box 2480  
Hollywood, FL 33022-2480  
Tel.: (954) 925-1100  
Fax.: (954) 925-1101

PCT/EP2005/050889  
2004P02085WOUS

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1 Description

2

3 Method for managing and monitoring the operation of a  
4 plurality of distributed hardware and/or software systems that  
5 are integrated into at least one communications network, and  
6 system for carrying out the method

7

8 The invention relates to a method for managing and monitoring  
9 the operation of a plurality of distributed hardware and/or  
10 software systems that are integrated into at least one  
11 communications network.

12

13 For reasons of cost and efficiency, more and more distributed  
14 hardware and/or software systems have recently been used in  
15 the business sector, in particular. Such systems can be  
16 operated in a virtual environment using the possibilities of  
17 "adaptive computing" in which, in a development of  
18 conventional systems, adaptation to the requirements of the  
19 current application is also possible in the hardware. Software  
20 systems which are becoming ever more complex are being  
21 operated in an increasingly heterogeneous hardware world. The  
22 assignment between software entities and hardware resources is  
23 no longer fixed but varies dynamically depending on the  
24 current requirements.

25

26 It is not possible to manage and monitor such distributed  
27 hardware environments using the conventional tools and  
28 monitoring tools which presuppose a fixed assignment between  
29 hardware and software. On account of the continuous dynamic  
30 configuration changes in the systems, which result, for  
31 example, from the self-healing mechanisms implemented by the  
32 system, the administrator's purely manual way of working is  
33 hardly practical any more.

34

35 Therefore, the invention is based on the object of specifying  
36 an improved method for managing and monitoring the operation

1 of a plurality of distributed hardware and/or software  
2 systems.

3  
4 In order to achieve this object, a method of the type  
5 mentioned initially provides, according to the invention, for  
6 a central program means that is stored in a data processing  
7 device to process system-related data which are present in the  
8 data processing device or are received by the latter via a  
9 communications network, to autonomously derive operation-  
10 related decisions from said data and, on the basis of said  
11 decisions, to generate decision-specific control data for  
12 influencing the operation of one or more hardware and/or  
13 software systems and to transmit said control data, via the  
14 communications network, to data processing devices which are  
15 assigned to the respective hardware and/or software systems.

16  
17 The central program means is thus capable of automatically and  
18 autonomously carrying out essential management, administration  
19 and monitoring tasks. It combines capabilities and functions  
20 which can nowadays be furnished only in part by administrators  
21 and system management and monitoring tools and which have  
22 hitherto not been able to be sufficiently furnished in the  
23 field of "adaptive computing". An important basis of the  
24 method according to the invention is the decision-making  
25 component of the central autonomous program means. Control  
26 data are generated on the basis of the decisions made in this  
27 manner and are forwarded to the individual systems which, for  
28 example, stop a hardware and/or software system or move a  
29 particular application. The control data are transmitted, via  
30 the communications network, to the individual systems which  
31 are affected by the respective decisions. In this manner, in  
32 the method according to the invention, the central program  
33 means undertakes numerous tasks which, in conventional  
34 hardware and software environments, are manually undertaken by  
35 administrators.

36

1 One development of the concept of the invention provides for  
2 the central program means to access rule data, which comprise,  
3 in particular, rules regarding priorities and/or sequences  
4 and/or logical and/or temporal relationships, and/or  
5 performance data, which relate, in particular, to the current  
6 operational load and/or the temporally restricted and/or  
7 dynamic and/or periodically needed capacity requirement,  
8 and/or grouping data and/or classification data and/or  
9 availability data, said data being stored in the data  
10 processing device. The rule data form a rule system which  
11 prescribes a basic structure for the management or  
12 administration and monitoring method. Priority rules may  
13 define, for example, the preference for the interactive mode  
14 over batch processing in an application entity. Sequences may  
15 determine which services have to be stopped first in the event  
16 of a stoppage. System components possibly have to resort to  
17 other systems or results provided by other system components.  
18 In such cases, it is necessary to take into account a number  
19 of logical and/or temporal relationships that the method  
20 obtains from the rule data. A software system requires  
21 sufficient hardware resources. In order to determine the  
22 capacities required and the regular operational load on the  
23 hardware systems, the performance data can again be accessed  
24 in the method according to the invention. Performance data  
25 relate, for example, to the current operational load or the  
26 capacity regularly required by an application that runs at  
27 certain intervals of time, for example. Said data provide a  
28 measure of the performance of the system environment. For  
29 effective management, it is also expedient to divide the  
30 system environment, together with its components and the tasks  
31 to be carried out by it, into different groups or classes. The  
32 associated grouping and classification data may  
33 correspondingly relate to structural aspects (for example in  
34 the case of identical hardware) and aspects as regards  
35 contents (for example in the case of components which interact  
36 in order to solve a problem). In addition, the method accesses  
37 data relating to the availability of individual systems. For

1 example, the method thus determines whether and where the  
2 resources, for example CPUs or main memories, needed for an  
3 application that is running according to plan are available.  
4

5 In addition, the invention provides for the system-related  
6 data to be operating plans, which regulate, in particular, run  
7 times and availability of individual hardware and/or software  
8 systems, and/or information regarding the operating state of  
9 individual systems, said information relating, in particular,  
10 to the current and/or future and/or periodic workload, and/or  
11 an operator's wishes which have been input at the central  
12 and/or individual system level using an input device. In  
13 contrast to the data mentioned in the preceding section, these  
14 system-related data are of a less general nature but rather  
15 relate more to the current operation of the systems. In this  
16 case, the central program means receives, for example, data  
17 regarding the fact that an application which accesses a  
18 database that is currently greatly burdened is currently  
19 running. If there is then a fault in an application entity and  
20 in a database entity required by the latter, the central  
21 program means can use these system-related data to access the  
22 rule data which comprise, for example, the fact that, in such  
23 a case, the fault in the database entity must be rectified  
24 first. In this case, it is necessary to take into account  
25 operator wishes, which a user can input at the central and/or  
26 individual system level using an input device, in order to  
27 ensure ease of operation and to enable variable operation.  
28

29 The central data processing device expediently receives the  
30 information regarding the operating state of individual  
31 systems in an active and/or passive manner. The task of  
32 receiving and collecting the information can thus be adapted  
33 depending on the conditions of the system environment. For  
34 example, it may be advantageous for the central data  
35 processing device to be provided, as standard, with routine  
36 data associated with normal operation, while it independently

1 actively requests special data in the case of faults or  
2 reconfiguration problems, for example.

3  
4 The invention provides for the information to relate to  
5 hardware in the form of clients and/or servers and/or networks  
6 and/or storage systems and/or software in the form of  
7 applications and/or distributed applications having services  
8 that are dependent on one another and/or distributed  
9 application systems having virtualized services that are  
10 dependent on one another and/or are independent of one another  
11 and/or databases and/or front ends. More or less system-  
12 related information regarding the hardware and software is  
13 required depending on the design of the underlying system  
14 environment. Server/client networks and storage units or  
15 storage systems are given an outstanding role in connected  
16 system environments. Databases are usually accessed from a  
17 plurality of systems, so that the information relating to the  
18 latter should be centrally available. The same applies to  
19 distributed application systems, in particular in the field of  
20 "adaptive computing", since in this case configuration changes  
21 have to be centrally monitored.

22  
23 Provision is expediently made for the control data which are  
24 generated by the central program means to control the starting  
25 and/or stopping and/or addition of services and/or the  
26 movement of services and/or applications and/or the  
27 maintenance of a distributed hardware and/or software system.  
28 In this manner, the central program means causes an  
29 application to be started or a hardware system to be stopped,  
30 for example. Individual services, for example interactive  
31 mode, batch processing, accounting, printing, messaging or a  
32 web service, can be added or, if they are no longer needed  
33 again or are needed again only after a particular period of  
34 time has elapsed, can be moved. Applications which are  
35 currently not required can similarly be moved. Maintenance,  
36 for example when installing and updating applications, can be  
37 centrally controlled in an analogous manner. Applications can

1 thus be installed autonomously and centrally on the basis of  
2 the acknowledgments which are received in the individual  
3 updating and installation steps. If an application environment  
4 is to be stopped again, the decision-specific control data are  
5 based, as when starting, on a sequence and alternative  
6 routines are heeded. It is also possible to reconfigure a  
7 software system, for example, in a similar manner.

8  
9 One refinement of the invention provides for the operation-  
10 related decisions to comprise the determination of  
11 administrative tasks and/or chains of tasks. A task may be,  
12 for example, the monitoring of a particular system. Chains of  
13 tasks comprise tasks that are to be executed in a particular  
14 order, for example the coordinated stopping of a plurality of  
15 systems.

16  
17 Provision is also made for the central program means to  
18 autonomously separate administrative tasks and/or chains of  
19 tasks into subtasks taking into account logical and/or  
20 temporal relationships and/or dynamic influences and/or  
21 availability data and/or priorities and/or grouping data  
22 and/or classification data and/or application data which are  
23 present in the data processing device, in particular for the  
24 purpose of moving and/or replacing application entities. If,  
25 for example, it is necessary to reconfigure a system  
26 environment, a chain of a large number of tasks needs to be  
27 executed for this purpose. An application whose functionality  
28 is based on a database can only be operated again after the  
29 database on account of the logical relationship. Temporal  
30 relationships exist if, for example, it is necessary to resort  
31 to earlier results. In addition, it may be expedient to only  
32 operate system entities of a particular class again in order  
33 to establish a basic functionality, for example. In this case,  
34 separation into subtasks makes it possible to execute chains  
35 of tasks in a locally distributed manner and to take into  
36 account temporal conditions.

37

1 It is also advantageous if the central program means checks  
2 the temporal progression of the administrative tasks and/or  
3 chains of tasks, which are transmitted to the individual  
4 hardware and/or software systems in the form of control data,  
5 continuously and/or at particular intervals of time. In this  
6 manner, faults and problems which possibly arise are  
7 discovered as a matter of routine in the course of operation.  
8 If necessary, the execution of a chain of tasks can be  
9 interrupted. However, variable reactions to the faults and  
10 problems, which go beyond interruption, are also possible on  
11 the basis of the available rule and performance data.

12  
13 One development of the invention provides for at least some of  
14 the distributed hardware and/or software systems to be  
15 assigned their own autonomous program means which are stored  
16 in data processing devices and are in the form of autonomous  
17 agents which are subordinate to the central program means. In  
18 this case, the autonomous program means or agents at the  
19 system level carry out administrative and monitoring tasks but  
20 they are subordinate to the central program means so that it  
21 is possible to avoid collisions in decisions which affect a  
22 plurality of systems in the system environment.

23  
24 Provision is also made for the autonomous agent of an  
25 individual hardware and/or software system to access rule data  
26 which are prescribed at the system level in the data  
27 processing devices and comprise, in particular, rules for the  
28 individual system and/or the interaction with the central  
29 autonomous program means. Depending on the stipulation of  
30 these rules, the autonomous agent makes decisions for his  
31 respective system on the basis of the rules insofar as said  
32 decisions do not fall within the regulating sphere of the  
33 central autonomous program means. If the autonomous agent  
34 cooperates with the central autonomous program means, this  
35 cooperation is again subject to rules so that, for example,  
36 both do not make operation-related decisions, which differ



1 from one another under certain circumstances, for the same  
2 area of the system.

3  
4 The central program means and the autonomous agents of the  
5 individual hardware and/or software systems expediently  
6 interchange control and/or rule data via the communications  
7 networks. In this manner, the central program means receives  
8 information regarding control processes which have been  
9 carried out at the system level, for example the movement of a  
10 service, and may coordinate the central management and  
11 administration therewith. Conversely, the autonomous agent at  
12 the system level requires information regarding the operations  
13 in which the central program means has intervened in the  
14 system in order to avoid collisions or to prevent individual  
15 tasks from being processed twice.

16  
17 It is advantageous if the central program means grants  
18 decision-making powers to the autonomous agents of the  
19 individual systems, and/or withdraws said decision-making  
20 powers, in a permanent or temporally restricted and/or dynamic  
21 manner using the communications networks. Such dynamic  
22 authorization makes it possible to react to changes in the  
23 system environment in a flexible manner. In the event of a  
24 fault, it is expedient, for example, for the central program  
25 means to be granted greater decision-making powers in order to  
26 first restore basic operation. In contrast, in the case of  
27 trouble-free operation, the decision-making powers of the  
28 autonomous agents can be increased if no problems are to be  
29 expected.

30  
31 The invention provides for the autonomous agents of the  
32 individual hardware and/or software systems to respectively  
33 transmit general and/or system-specific control data to the  
34 data processing device of the central program means via a  
35 communications network and/or to publish said data in  
36 generally accessible file systems and/or to collaborate in the  
37 separation of administrative tasks and/or chains of tasks into

1 subtasks. The term publication means that data which are of  
2 interest beyond individual system levels are made available to  
3 the central program means or else to other subsystems using a  
4 generally accessible file system (blackboard). Separating the  
5 tasks at the individual system level eases the burden on the  
6 central program means and dividing the tasks into subtasks at  
7 the individual system level is also more expedient in specific  
8 systems.

9  
10 One development of the invention provides for the central  
11 program means to be operated in different operating modes, in  
12 particular in a fully autonomous or partially autonomous  
13 manner and/or with different reaction speeds. These different  
14 operating modes can be selected depending on the current  
15 operating conditions. Simple standard operation can be carried  
16 out in a fully autonomous manner but partially autonomous  
17 operation will generally be expedient in the event of faults.  
18 The speed at which the means react to a given situation needs  
19 to be orientated to all of the operations which take place in  
20 the system environment. In the individual case, a slow  
21 reaction may be expedient in order to conclude a particular  
22 operation before the reaction. In the case of relatively great  
23 problems, it is often necessary to react quickly in order to  
24 prevent a chain of resultant problems.

25  
26 Provision is expediently made for the operation of the central  
27 program means in the partially autonomous mode to be changed  
28 and/or interrupted by manual inputs on an input device by an  
29 authorized administrator. This ensures that, in the case of  
30 rare problems or faults or else special operating requirements  
31 for which there are no rules under certain circumstances,  
32 operation can still be controlled manually.

33  
34 In addition, it may be expedient for the operation of the  
35 central program means in the partially autonomous mode to be  
36 changed and/or interrupted by the autonomous agents of the  
37 individual systems. Such a restriction of the autonomous

1 operation of the central program means is expedient when the  
2 autonomous agents at the individual system level are working  
3 on their system in a comparatively independent manner without  
4 interchanging a relatively large amount of data with the  
5 central program means, with the result that, in the event of a  
6 fault, the central program means may be lacking information  
7 which the autonomous agent has and which renders it necessary  
8 to change the central operation. The autonomous agent can then  
9 arrange for this change to be made.

10  
11 It is advantageous if the central program means comprises a  
12 notification component which uses an output device to output  
13 information regarding substeps of the work of the central  
14 program means and/or the processing state thereof. An  
15 administrator or operator thus receives information regarding  
16 the progression of system operation and accordingly knows, for  
17 example, when tasks whose results he requires will be  
18 concluded. In addition, the administrator can coordinate any  
19 possible planned manual interventions with the given  
20 processing state. Malfunctions can be quickly detected.

21  
22 One refinement provides for the distributed hardware and/or  
23 software systems to comprise at least one application system.  
24 The at least one application system may comprise a plurality  
25 of entities which each control at least one service, in  
26 particular interactive mode and/or batch mode and/or  
27 accounting and/or printing and/or messaging and/or network  
28 services. Messaging services make it possible to communicate  
29 and interchange notifications, while network services are  
30 responsible, on the one hand, for internal networks and, on  
31 the other hand, for the connection to principally external  
32 networks such as the Internet, for example in the form of web  
33 services. The different entities of an application form a  
34 logical system with corresponding relationships.

35  
36 Provision is also made for a plurality of application systems  
37 to cooperate in a system family. This constellation is typical

1 of relatively large configurations, in which a number of  
2 relationships can again exist between the individual systems  
3 if, for example, application systems are placed on one another  
4 or condition one another.

5  
6 In addition, it is possible for at least one application  
7 system to be operated in a virtual environment without fixed  
8 hardware assignment. The use of the method according to the  
9 invention using the central autonomous program means is  
10 particularly advantageous, in particular, in such a case if  
11 the assignment between the application and the hardware varies  
12 and cannot be readily identified from the outside since  
13 conventional management and administration methods provide  
14 only insufficient and complicated solutions in this case.

15  
16 Provision is also made for the distributed hardware and/or  
17 software systems to comprise client/server systems and/or  
18 operating systems. Client/server systems are of central  
19 importance in modern computer environments. This applies, in  
20 particular, in "adaptive computing". The corresponding  
21 operating systems form the connection to the application  
22 systems.

23  
24 In addition, the invention relates to a system for managing  
25 and monitoring the operation of a plurality of distributed  
26 hardware and/or software systems that are integrated into at  
27 least one communications network, said system comprising a  
28 data processing device and a central autonomous program means  
29 that is stored in the latter and/or autonomous agents (which  
30 are stored in data processing devices) for individual hardware  
31 and/or software systems and/or input and/or output devices at  
32 the central and/or individual system level and being designed  
33 to carry out the method as described above.

34  
35 Further advantages, features and details of the invention will  
36 be described below with reference to a particularly suitable  
37 exemplary embodiment.

1  
2 The figure shows a schematic diagram for carrying out the  
3 method according to the invention.

4  
5 The central program means is stored in a data processing  
6 device which is not illustrated here. There is a connection to  
7 an input/output device. In this case, an operator or  
8 administrator can effect inputs, for example in order to  
9 change or interrupt the operation of a central program means  
10 that is operating in the partially autonomous mode, or can  
11 follow up the notifications from the central program means  
12 regarding the substeps of the work and the processing state of  
13 the latter. Two system families x and y which comprise, for  
14 example, cooperating applications are subordinate to the  
15 central program means. Each of the two system families  
16 comprises two subsystems, the systems A and D and B and C.

17  
18 The central program means and the individual systems are each  
19 mutually related to the blackboards (generally accessible file  
20 systems). The individual systems publish, if appropriate,  
21 general and/or system-specific control data, which are not  
22 only intended to be accessible to the central program means  
23 but also to further individual systems, on the blackboards  
24 using their autonomous agents, in particular. This is  
25 interesting when the data can affect other systems, for  
26 example when applications mutually depend on one another. The  
27 individual systems, for their part, provide the central  
28 program means with control and rule data via communications  
29 networks. In addition, they collaborate in the separation of  
30 administrative tasks or chains of tasks into subtasks.

31  
32 The systems A - D are responsible for different services a -  
33 1. These services may comprise, for example, interactive or  
34 batch processing, accounting, printing, messaging and web  
35 services. The systems are operated in a distributed manner,  
36 with the result that the services associated with a system are  
37 respectively implemented in different autonomous individual

1 systems. In the case illustrated, these individual systems are  
2 autonomous hardware systems 1 - 5 which are composed of  
3 heterogeneous hardware components. Each system is provided  
4 with individual hardware and an operating system (not  
5 illustrated here). The services a and d of the system A run on  
6 the autonomous individual system 1 and the service d is  
7 simultaneously also operated in the individual system 3, while  
8 a further service e of the system A is located in the  
9 individual system 4. This assignment of the services of the  
10 systems A - D to the individual systems 1 - 5 varies  
11 dynamically depending on the current requirements of the  
12 overall system environment. There is no fixed assignment  
13 between the application and the hardware resources. For  
14 example, the service j, which belongs to the application  
15 system D and is initially running on the autonomous individual  
16 system 3, is changed over to operation in the autonomous  
17 individual system 5.

18  
19 The autonomous agents of the individual systems and the  
20 central program means collect and process information  
21 regarding operation taking into account the changing  
22 assignments and derive autonomous decisions from said  
23 information. Since the individual systems A - D, for their  
24 part, have the autonomous powers (not illustrated here), the  
25 amount of information that needs to be interchanged overall in  
26 the system environment is reduced and a multiplicity of  
27 reaction possibilities which can each be attributed to simple  
28 reactions are produced. The central program means can be  
29 operated in a fully autonomous or partially autonomous manner.  
30 In the partially autonomous mode, the operation of the central  
31 program means can be changed or interrupted by inputs by an  
32 administrator on the input/output device or by the autonomous  
33 agents of the individual systems. Since there is no fixed  
34 assignment between the hardware and software, it is possible  
35 to utilize and make full use of the hardware resources in an  
36 optimum manner. As illustrated here, the same services may run  
37 on different autonomous individual systems. For example, the

1 service e can be operated in the individual systems 2, 4 and  
2 5. If one of these systems is particularly burdened, the  
3 application system which is responsible for this service, for  
4 example, can alternatively allow the service to run on another  
5 hardware system. The central program means also enables  
6 effective management and effective monitoring and  
7 administration in such a case of "adaptive computing" having  
8 virtual environments.

9  
10